THIS BOX MUST BE COMPLETED

Student Code No. ....

Student's Signature ....

Date Submitted ....

Contact e-mail ....

MODULE TITLE : MASS AND ENERGY BALANCE

TOPIC TITLE : ENERGY BALANCE

TUTOR MARKED ASSIGNMENT 3

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MAEB - 3 - TMA (v1)

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IMPORTANT

Before you start please read the following instructions carefully.

1. This assignment forms part of the formal assessment for this module. If you fail to reach the required standard for the assignment then you will be allowed to resubmit but a resubmission will only be eligible for a Pass grade, not a Merit or Distinction.

   You should therefore not submit the assignment until you are reasonably sure that you have completed it successfully. Seek your tutor's advice if unsure.

2. Ensure that you indicate the number of the question you are answering.

3. **Make a copy** of your answers before submitting the assignment.

4. **Complete all details on the front page of this TMA** and return it with the completed assignment including supporting calculations where appropriate. The preferred submission is via your TUOL(E) Blackboard account:

   https://eat.tees.ac.uk

5. Your tutor's comments on the assignment will be posted on Blackboard.

Attempt **ALL** questions.

1. (a) Define:

   (i) specific heat capacity
   (ii) molar heat capacity.

   (b) Distinguish between:

   (i) heat capacity at constant volume and constant pressure
   (ii) internal energy and enthalpy
   (iii) sensible heat and latent heat.

   (c) State the First Law of Thermodynamics as applicable to energy balance.

2. Identify a process you are familiar with from your job (or everyday experience), which involves at least two different gases (you could for example use methane and air in a gas cooker if no other suitable alternative is available). Note the normal temperature (°C) of the gases in use.

   (a) Estimate the molar heat capacity at constant pressure (C_p in J mol^{-1} K^{-1}) for **each** gas at its normal operating temperature using:

   (i) the correlation

   $C_p = a + bT + cT^2 + dT^3$ where a, b, c and d are constants to be obtained from a relevant source and T is in K.

   (ii) any other method (quote the source of data so it can be checked).

(b) Comment on the difference (if any) between the two answers for **each** gas obtained in (a).

(c) Estimate the mean molar heat capacity at constant pressure over the range 273 K to *T* K and hence calculate the change in enthalpy over that range for **each** gas.

3. (a) Write the balanced chemical equation for the complete combustion of 1 mole of liquid methanol (CH_3OH) to carbon dioxide ($CO_{2\,(g)}$) and water ($H_2O_{(g)}$).

(b) Using the data given, calculate the standard heat of reaction (combustion) when methanol is completely burned in air.

Data:

ΔH_f° of $H_2O_{(g)}$ = – 242.1 kJ mol^{-1}
ΔH_f° of $CO_{2\,(g)}$ = – 393.8 kJ mol^{-1}
ΔH_f° of $CH_3OH_{(l)}$ = – 238.7 kJ mol^{-1}

(c) Using the answer obtained in (b) and the data given below, calculate the standard heat of reaction (combustion) of methanol at 300°C.

Data:

Mean specific heat capacities over the range 25°C to 300°C for
$CO_{2\,(g)}$ = 32.0 J mol^{-1} K^{-1}
$H_2O_{(g)}$ = 36.5 J mol^{-1} K^{-1}
$O_{2(g)}$ = 30.0 J mol^{-1} K^{-1}
$CH_3OH_{(l)}$ = 50.0 J mol^{-1} K^{-1}

(d) (i) Using the answer from (b) calculate a value for the heat of reaction (combustion) of methanol at constant volume.
Take $R = 0.0083$ kJ mol^{-1} K^{-1}.

(ii) Give **one** instance where the heat of reaction at constant volume may be required rather than the one at constant pressure.

4. Fuel oil is to be heated in a heat exchanger using steam under the following conditions:

Inlet temperature of oil = 40°C.
Outlet temperature of oil = 120°C.
Flow rate of oil = 420 kg h^{-1}.
Mean specific heat capacity of oil = 2.05 kJ kg^{-1} K^{-1}.
Temperature of steam = 165°C (dry saturated).
Temperature of steam condensate = 130°C
8% of the heat is lost to the atmosphere (i.e. process is 92% efficient).

(a) Using steam tables, find:

(i) the specific latent heat of vaporization of steam (h_{fg}) at 165°C in kJ kg^{-1}

(ii) the difference in enthalpy of liquid water (h_f) between 165°C and 130°C in kJ kg^{-1}.

(b) Calculate the quantity of this steam required per hour to perform this duty.

Question No.	